AD-A231 289

Report No. NADC-90065-60

DTIC ELECTE JAN 29 1991 S D

THE DEVELOPMENT OF PERCEPTUAL/MOTOR AND COGNITIVE PERFORMANCE MEASURES UNDER A HIGH-G ENVIRONMENT: A PRELIMINARY STUDY

LCDR John E. Deaton, LT Michael Holmes
Norman Warner, Ph.D., and Edward Hitchcock
Air Vehicle and Crew Systems Technology Department (Code 6021)
NAVAL AIR DEVELOPMENT CENTER
Warminster, PA 18974-5000

4 SEPTEMBER 1990

FINAL REPORT
Period Covering December 1988 to April 1990
Task No. A-41
Program Element No. 62122N
Project No. RR22

Approved for Public Release; Distribution is Unlimited

Prepared for
OFFICE OF NAVAL TECHNOLOGY (ONT-212)
800 N. Quincy St.
Arlington, VA 22217

NOTICES

REPORT NUMBERING SYSTEM — The numbering of technical project reports issued by the Naval Air Development Center is arranged for specific identification purposes. Each number consists of the Center acronym, the calendar year in which the number was assigned, the sequence number of the report within the specific calendar year, and the official 2-digit correspondence code of the Command Officer or the Functional Department responsible for the report. For example: Report No. NADC-88020-60 indicates the twentieth Center report for the year 1988 and prepared by the Air Vehicle and Crew Systems Technology Department. The numerical codes are as follows:

CODE	OFFICE OR DEPARTMENT
00	Commander, Naval Air Development Center
01	Technical Director, Naval Air Development Center
05	Computer Department
10	AntiSubmarine Warfare Systems Department
20	Tactical Air Systems Department
30	Warfare Systems Analysis Department
40	Communication Navigation Technology Department
50	Mission Avionics Technology Department
60	Air Vehicle & Crew Systems Technology Department
70	Systems & Software Technology Department
80	Engineering Support Group
90	Test & Evaluation Group

PRODUCT ENDORSEMENT — The discussion or instructions concerning commercial products herein do not constitute an endorsement by the Government nor do they convey or imply the license or right to use such products.

Reviewed By: John E. Deaton Date: 19 Oct 90
Branch Head

Reviewed By: [signature] Date: 23 OCT 90
Division Head

Reviewed By: [signature] Date: 24 Oct 90
Director/Deputy Director

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1a REPORT SECURITY CLASSIFICATION
Unclassified

1b RESTRICTIVE MARKINGS

2a SECURITY CLASSIFICATION AUTHORITY

2b DECLASSIFICATION / DOWNGRADING SCHEDULE

3 DISTRIBUTION / AVAILABILITY OF REPORT
Approved for Public Release;
Distribution is Unlimited

4 PERFORMING ORGANIZATION REPORT NUMBER(S)
NADC-90065-60

5 MONITORING ORGANIZATION REPORT NUMBER(S)

6a NAME OF PERFORMING ORGANIZATION
Air Vehicle and Crew Systems Technology Dept.

6b OFFICE SYMBOL (If applicable)
6021

7a NAME OF MONITORING ORGANIZATION

6c ADDRESS (City, State, and ZIP Code)
NAVAL AIR DEVELOPMENT CENTER
Warminster, PA 18974-5000

7b ADDRESS (City, State and ZIP Code)

8a NAME OF FUNDING / SPONSORING ORGANIZATION
OFFICE OF NAVAL TECHNOLOGY

8b OFFICE SYMBOL (If applicable)
ONT-212

9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c ADDRESS (City, State, and ZIP Code) William King
Office of Naval Technology
800 N. Quincy St.
Arlington, VA 22217

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO
62122N	RR22	A-41	

11 TITLE (Include Security Classification)
The Development of Perceptual/Motor and Cognitive Performance Measures Under a High G Environment: A Preliminary Study

12 PERSONAL AUTHOR(S) LCDR John E. Deaton, LT Michael Holmes, Dr. Norman Warner, Edward Hitchcock

13a TYPE OF REPORT
Final

13b TIME COVERED
FROM 12/88 TO 4/90

14 DATE OF REPORT (Year, Month, Day)
1990 September 4

15 PAGE COUNT

16 SUPPLEMENTARY NOTATION

17 COSATI CODES

FIELD	GROUP	SUB-GROUP

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Human Factors, Acceleration, Cognitive Performance, Perceptual/Motor Performance, Centrifuge, Seat Supination, G Forces

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

There is currently a lack of data on the operator's ability to perform flight and weapon systems management functions under a high-G environment. The ability to correctly track enemy targets and respond with appropriate countermeasures is dependent upon the operator's ability to perform both perceptual/motor and cognitive functions. At the present, not enough information is available to determine how these two functions operate under high-G. The purpose of this investigation was to design both a perceptual/motor task as well as a task to measure cognitive decrement in human subjects exposed to a high-G environment. The primary objective was to develop and validate the utility of these tasks for eventual incorporation into a subsequent investigation that will examine the effect of high-G on these performance measures as a function of type of seat supination: fixed versus inclined.

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21 ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a NAME OF RESPONSIBLE INDIVIDUAL
LCDR John E. Deaton

22b TELEPHONE (Include Area Code)
(215) 441-3119

22c OFFICE SYMBOL
Code 6021

DD Form 1473, JUN 86 Previous editions are obsolete. SECURITY CLASSIFICATION OF THIS PAGE

S/N 0102-LF-014-6603 UNCLASSIFIED

CONTENTS

FIGURES

TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

INTRODUCTION

There is currently a lack of data on the operator's ability to perform flight and weapon system management functions under a high G environment. A few studies have, however, investigated tracking performance during acceleration (Rogers, 1973;[3] Glaister & Lisher, 1976)[1], while Lisher & Glaister (1987)[2] examined the effect of acceleration on performance of a reaction time task. The ability to correctly track enemy targets and respond with appropriate countermeasures is dependent upon the operator's ability to perform both perceptual/motor and cognitive functions. At the present, not enough information is available to determine how these two functions operate under high G. More importantly, before an assessment can be made regarding performance under high G, an appropriate experimental methodology must be developed to capture subject data during very brief (perhaps 15 seconds or less) performance sessions. To exceed this performance window at high G would place the subject at risk. The challenge, therefore, lies in developing performance assessment tasks in which a "sufficient" amount of data can be collected during very brief time periods.

In addition to the problem of collecting performance data during brief exposures to different G levels, there is also the problem of interpreting the performance data. More specifically, are G-induced performance decrements due to non-cognitive factors such as visual narrowing and distortion, cognitive processing deficits, or both? To entirely understand any G-induced performance changes, the sensory and cognitive components of performance need to be distinguished.

The purpose of this investigation was to design both a perceptual/motor task as well as a task to measure cognitive decrement in human subjects exposed to a high-G environment. The present study has eliminated the above mentioned potential confounds that typically surround acceleration research. Two tasks were developed and evaluated in this investigation. The primary objective of this research was to develop and validate the utility of perceptual/motor and cognitive tasks for eventual incorporation into a subsequent investigation, that will examine the effect of high G on these performance measures as a function of type of seat supination: fixed versus inclined.

METHOD

SUBJECTS

Subjects consisted of 15 Naval Air Development Center (NADC) employees, 3 females and 12 males, who volunteered in response to a request for subjects placed in the Base newsletter. Subjects ranged in age from 27 to 56 years with a mean of 39 years. All subjects reported having normal or corrected to normal vision. Subjects reporting the use of medications or similar substances that might affect performance were not included in the investigation.

EXPERIMENTAL TASKS

The experiment was conducted on a Zenith 286 microcomputer utilizing the keyboard and mouse for response inputs. The arrangement of the computer was of a normal desktop configuration, with the monitor placed above and behind the keyboard, and the mouse to the right. Subjects were allowed to position themselves in any manner that was most comfortable for them. The two tasks designed for the experiment included (1) a perceptual/motor tracking task, and (2) a cognitive task (with two levels of difficulty), positioned on the display so that the cognitive task was directly below the tracking task. The perceptual/motor tracking task consisted of two moving lines, one vertical and one horizontal, presented in a two dimensional plane (see Figure 1).

The objective of the tracking task was to keep the crossbars centered in the marks via mouse inputs. The cognitive task consisted of computer generated sets of four symbols presented

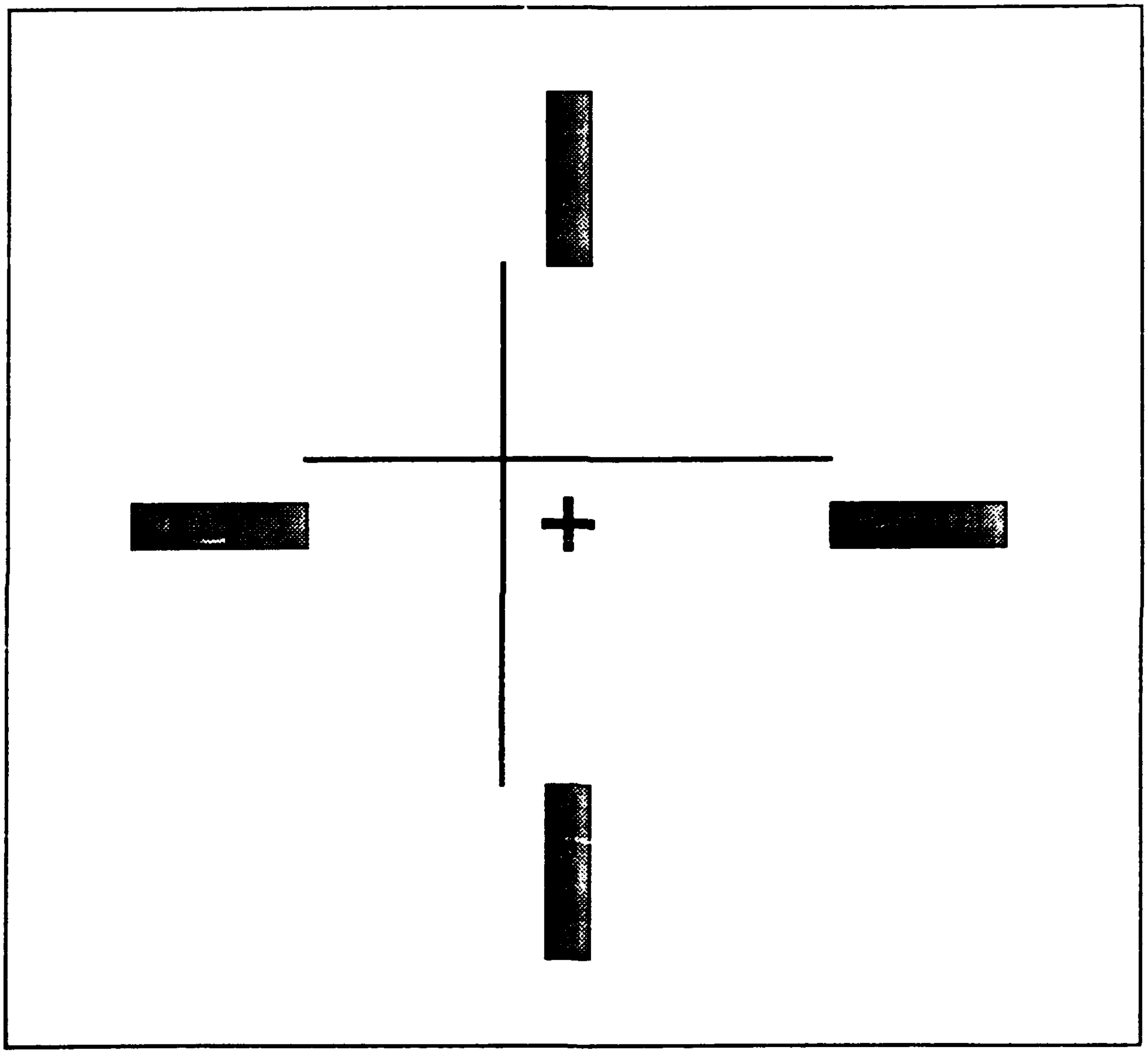

Figure 1. Perceptual-Motor Task.

simultaneously to the subject and displayed until the subject responded. The sets were presented at an inter-stimulus rate of 0.6 seconds. Each of the symbols had an assigned value associated with it, which remained constant throughout the experiment. The symbols used were a square, circle, a plus sign, and a triangle. The values associated with these symbols were one, two, three, and four, respectively (see Figure 2).

Subjects were required to interpret the corresponding values associated with each symbol. These values were given in the instruction sheet and remained visibly displayed to the subject on an individual reference sheet throughout the entire experimental session. The cognitive task consisted of two different conditions. In the first condition, labeled Condition A, subjects were required to discern whether "odd" or "even" symbols (based on the symbols' associated values) were of a majority set presented in each trial. The second condition, Condition B, as similar to Condition A, in that the subjects were to determine which type of symbols, "odd" or "even", were of the majority depicted in the symbol set. Once determined, however, the subjects then calculated the numerical sum of the the majority symbols' corresponding values and compared this sum to a given target value displayed below the symbol set (see Figure 3).

The symbol sets were randomly generated with the following constraints: (1) the symbols in the set could not all be the same type; (2) the symbols in the set could not be all different; this is because neither "odd" or "even" would be of a majority, and for the same reason, two-of-a-kind pairs of "odd" and "even" could not appear in the same set; (3) for Condition A, "odd" and "even" sets of symbols would have an equal ratio of "odd" sets and "even" sets; (4) same constraint as above for Condition B, except that 50 percent of the time the target value would be greater than the sum of the majority symbols, and 50 percent of the time it would be less. A specific keyboard input was used to record the responses in each of the conditions.

For this experiment, the [A] and [F] keys were chosen in response to keys to be used. In Condition A, the [A] key corresponded to the majority of the symbols being "even" and the [F] key to the majority being "odd". In Condition B, the [A] key corresponded to the sum of the numerical values of the majority symbols being less than the display target value, and the [F] key corresponded to the same of the numerical values of the majority symbols being greater than the target value. For example, given the trial set consisting of a circle, plus sign, triangle, and another circle, the corresponding values for these symbols is 2 (circle), 3 (plus sign), 4 (triangle), and 2 (circle), with the "even" symbols being in the majority. The sum of these symbols equals eight. If the target value is nine, the correct response would be [A] since it is less than the target value displayed. Response feedback, in the form of an auditory tone, was given to each subject following each keyboard input. A high pitched tone denoted a correct response and a low pitched tone an incorrect response. Auditory feedback was initially given to promote learning the tasks, and continued in the experimental sessions to maintain a high level of motivation.

As pointed out earlier, the unique feature of this study was the development of a methodology to assess the role that cognitive or non-cognitive factors play in task performance at high G. In order to answer this question, two cognitive task conditions, A and B, were developed along the same lines as a traditional Sternberg (1969)[4] task. While it is true that Task A is a cognitive task, we also assume that it involves some non-cognitive features (e.g. the sensory system must be involved in the initial stages of feature discrimination). It is also true that Task B includes both cognitive, and to a lesser extent, non-cognitive factors. However, in the case of Task B, an additional cognitive processing stage is included (the classification of the total sum of the symbols' values as either less than or greater than the target value). This is, Task A consists of non-cognitive factors (call them a_1 and a_2) and cognitive factors (b_1 b_2 b_3) while Task B consists of the identical factors associated with Task A, except that Task B also requires an additional processing step (c_1 c_2). Thus, the only difference between tasks, is that Task B includes an additional cognitive processing requirement (c_1 c_2).

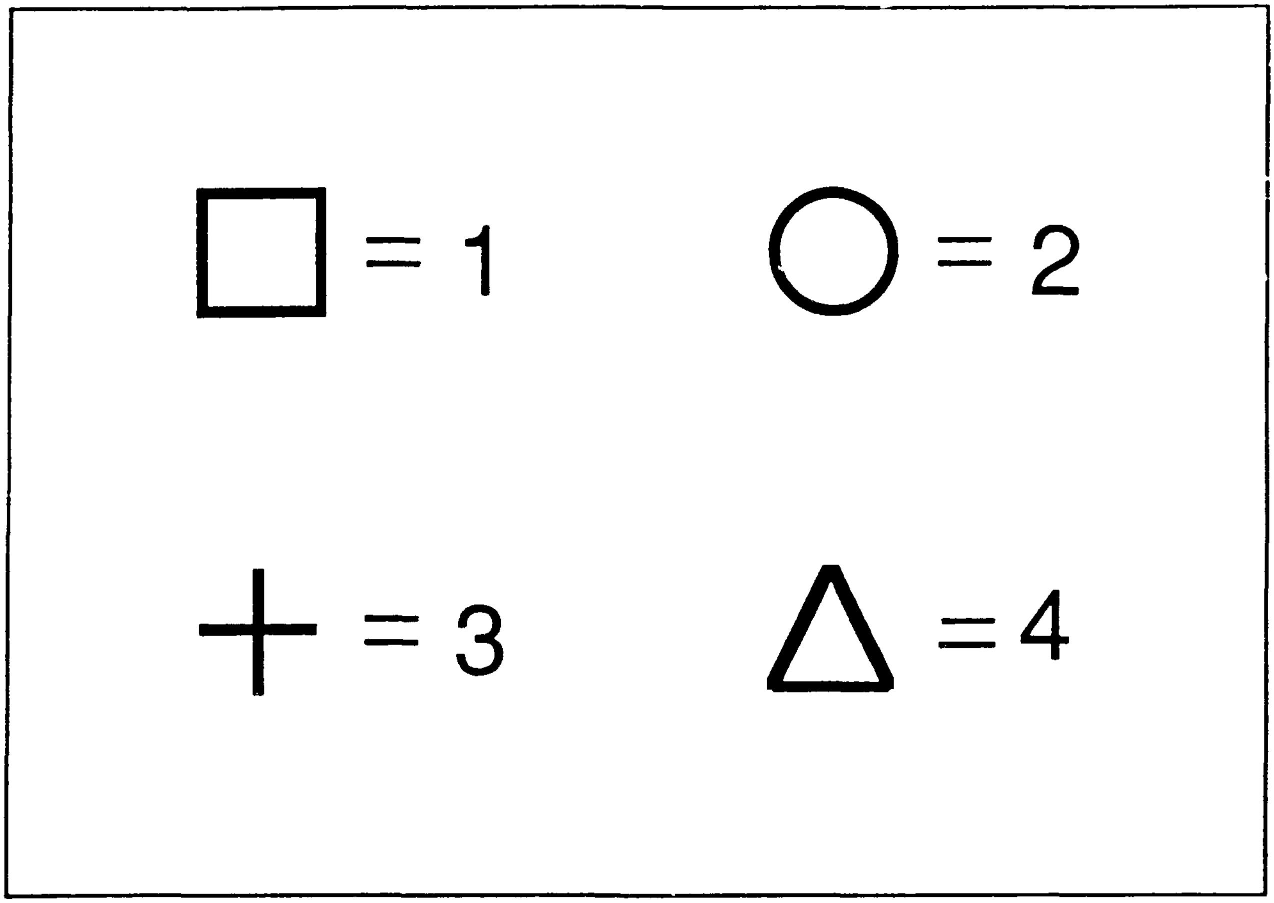

Figure 2. Symbols and Associated Values Used in both Cognitive Task Conditions.

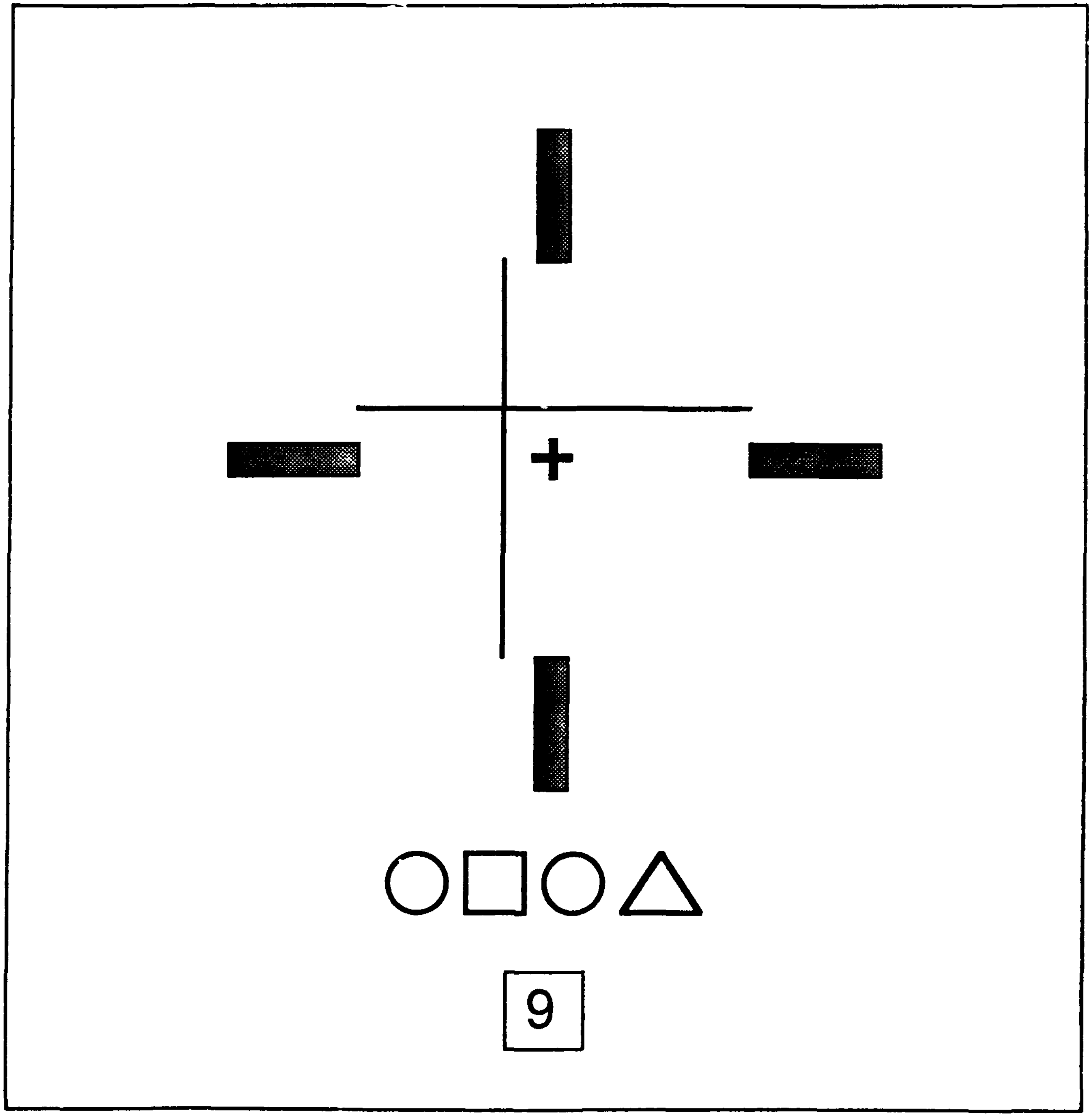

Figure 3. Dual Task Presentation Display Under Cognitive Condition B.

Using the same kind of logic involved in the Sternberg's memory-search paradigm, it should be possible to plot performance as a function of task difficulty, and G level to determine whether decrements are the result of cognitive or non-cognitive factors. For example, suppose our results indicate the relationship shown in Figure 4(a). Here we see no difference in performance as a function of G level of Task A, but a substantial performance decrement for Task B. If only Task A data were available, we would have erroneously concluded that G level does not affect task performance. However, with both tasks available, we can determine the precise relationship between G level and performa :ce.

Using the logic presented above, we know the difference in performance for Task B cannot be due to non-cognitive factors since both tasks must be identical sensory requirements (a_1 and a_2). The difference must be attributed to the additional cognitive (central processing) factors required in Task B. The conclusion to be drawn from this example, is that deficits at higher levels of G are most likely due to cognitive decrements rather than, say, visual field narrowing (sensory factors).

On the other hand, suppose we find a result similar to that shown in Figure 4(b). Here, overall performance at high G is worse than that at low G, but the rate of change between tasks remains the same (i.e., the lines have identical slope). In this example, we would have also concluded that G level affects performance, but the determination of which factor (cognitive or non-cognitive) is responsible for the decrement is different. In this case, the data suggests that differences in performance between low and high G are probably due to non-cognitive (sensory) factors. That is, since the difference in performance between low and high G levels is identical regardless of task condition, this difference must be associated with a factor which is common to both tasks; namely, sensory features. The central processing requirements for Task A and Task B do by design, differ, and thus cannot be responsible for similar performance differences within tasks. Their contribution must be negligible, otherwise, it would be very unlikely to find identical slopes. At very high levels of G, it could be proposed that these differences were most likely due to visual field distortions.

Determining the relative contributions of cognitive and non-cognitive factors to performance will be particularly essential when these tasks are incorporated into the primary study to be conducted on the centrifuge.

PROCEDURE

Upon entering the test area, subjects were given the task instruction sheet to read, and any questions that remained were answered. The structure of the practice session was then described by the experimenter. The practice sessions consisted of five, 10 minute sessions presented in the following order: (1) tracking task alone, (2) Condition A alone, (3) Condition A with the tracking task, (4) Condition B alone, and (5) Condition B with the tracking task. During the four sessions which utilized Conditions A and B, cognitive task stimuli symbol sets were displayed until the subject made a response.

The experimental session consisted of the same task duration, however, the order of presentation was counterbalanced among the 15 subjects. Between each task, subjective rating of workload were obtained using the NASA Task Load Index (TLX) (Hart & Staveland, 1988)[5]. The TLX was presented on the screen and the subjects were given instruction on how to complete the index.

The NASA TLX is a multi-dimensional rating procedure that provides an overall workload score based on a weighted average of ratings on six subscales: (1) Mental Demands (MD); (2) Physical Demands (PD); (3) Temporal Demands (TD); (4) Own Performance (OP); (5) Effort (EF); and (6) Frustration (FR). The extent to which each subscale contributes to overall workload was determined by subject responses to pairwise comparisons among the six scales. There were 15 possible pairwise

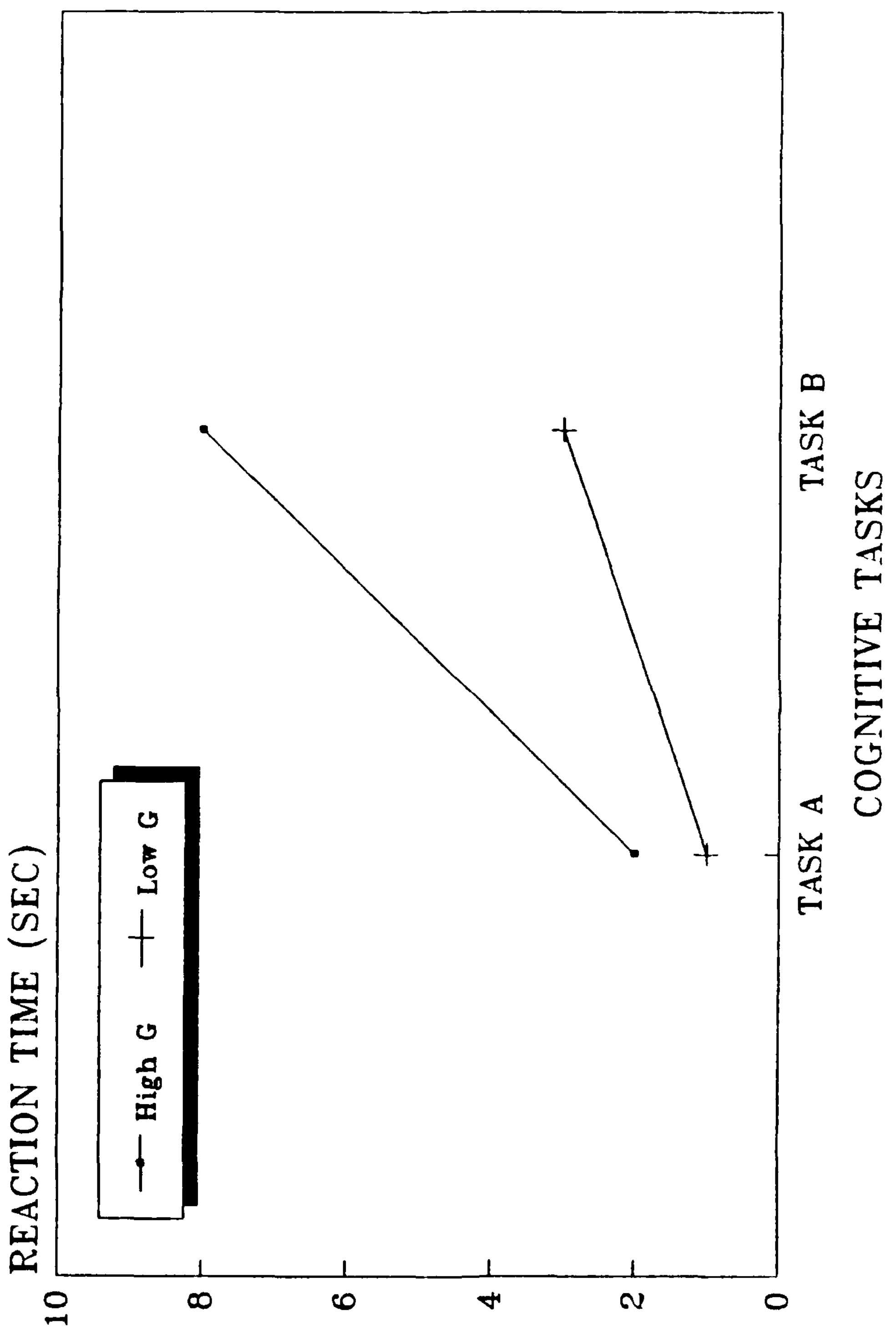

Figure 4a. Predicted Performance for Cognitive Tasks: Cognitive Deficit.

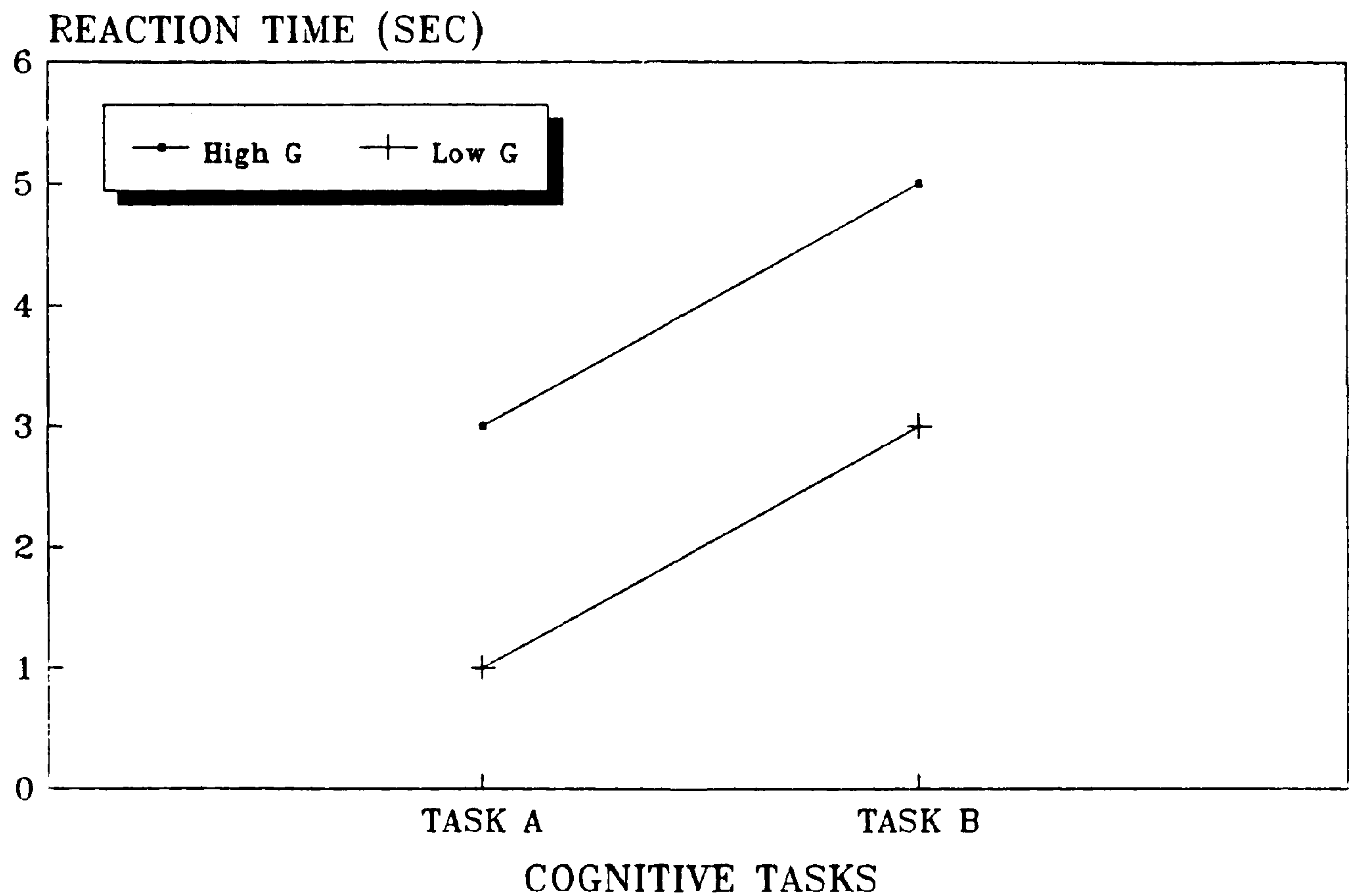

Figure 4b. Predicted Performance for Cognitive Tasks: Non-Cognitive Deficit.

comparisons among the six scales. Subjects selected the member of each pair which contributed the most to the workload of that task. This part of the evaluation procedure provided the weights, which could range from 0 (not relevant) to 5 (more important than any other factor). The second part of the evaluation procedure required subjects to rate the magnitude of each factor on a Likert-type scale. Each scale was presented as a line divided into 20 equal intervals anchored by bipolar descriptors like "High"/"Low". Each interval on the line represented a value of five. Thus, a particular factor could be assigned a rating ranging from 0 to 100. An overall workload score was computed by multiplying each factor rating by its associated weight. This sum of weighted ratings for each task was then divided by 15 (the maximum sum of the weights) to provide an overall weighted workload score (WWL). Both the raw scores associated with each of the six scales, and the overall weighted workload score could range in value from 0 to 100.

PERFORMANCE MEASURES

The experiment was designed so that single and dual task performance measures, composed of several different dependent variables, could be obtained. The tracking task was evaluated using a root-mean-square error (RMSE) analysis. The cognitive tasks were assessed using mean reaction time, as well as percent correct. The TLX was used to gather workload measurements on single and dual performance.

RESULTS

TRACKING TASK

Table 1 shows the Mean RMS Error for: (1) the tracking task, (2) tracking task with Condition A, and (3) tracking task with Condition B. These data were submitted to a 5 x 3 (5 levels of order x 3 tracking tasks) factorial analysis of variance, with repeated measures on the last factor. This analysis indicated a significant main effect for tracing, $\underline{F}(2,20) = 14.07$, $\underline{p}$, .001. Tracking alone demonstrated the smallest RMS error (1.58), while tracking with Condition B produced the largest RMS error (3.32). A Newman-Keuls post-hoc analysis revealed significant differences between: (1) tracking, and tracking with Condition A ($\underline{p} < .01$), and (2) tracking, and tracking with Condition B ($\underline{p} < .01$). There was no significant difference between tracking with Condition A and tracking with Condition B in terms of RMS error. That is, tracking was not affected by the difficulty level of the cognitive task. The main effect for order and the interaction of order x tracking were not significant.

COGNITIVE TASK

Table 2 shows the Mean Correct Response for : (1) Condition A, (2) Condition B, (3) Condition A with tracking, and (4) Condition B with tracking. A 5 x 4 (5 levels of order x 4 levels of cognitive task) factorial analysis of variance, with repeated measures on the last factor, was computed on the percent correct response data. None of the effects were significant. That is, cognitive performance was similar regardless of difficulty and despite the fact that, in two conditions, dual task performance was required.

RESPONSE TIMES

Table 3 shows the Mean Correct Response Latency data for: (1) Condition A, (2) Condition B, (3) Condition A with tracking, and (4) Condition B with tracking. The resulting 5 x 4 (5 levels of order x 4 levels of response condition) repeated measures factorial analysis of variance indicated a significant main effect for response condition, $\underline{F}(3,30) = 25.25$, $\underline{p}$, .001. Condition A alone, resulted in the most rapid response latency (0.93 sec), while Condition B with tracking, produced the longest response delay (3.68 sec). A Newman-Keuls analysis revealed significant differences between: (1) Condition A and Condition B ($\underline{p}$, .01), (2) Condition A and Condition B with tracking ($\underline{p} < .01$, (3) Conditions B and

Table 1.

Root Mean Square Error For Tracking Conditions.

TASK CONDITION	RMS ERROR (MEAN)	STANDARD DEVIATION
TRACKING	1.58	1.06
Tracking w/Cognitive (Condition A)	2.59	1.87
Tracking w/Cognitive (Condition B)	3.32	2.23

Table 2.

Mean Correct Response For Cognitive Task Conditions.

TASK CONDITION	MEAN CORRECT (%)	STANDARD DEVIATION
Cognitive (A)	97.3	0.58
Cognitive (B)	95.2	0.82
Cognitive (A) w/Tracking	94.0	3.26
Cognitive (B) w/Tracking	94.7	1.55

Table 3.

Mean Response Latency For Cognitive Conditions.

TASK CONDITION	MEAN RESPONSE (SEC)	STANDARD DEVIATION
Cognitive (A)	0.93	0.40
Cognitive (B)	3.19	1.44
Cognitive (A) w/Tracking	1.28	0.88
Cognitive (B) w/Tracking	3.68	2.02

Condition A with tracking ($p < .01$), (4) Condition B and Condition A with tracking ($p < .01$), and (5) Condition A with tracking and Condition B with tracking ($p < .01$). Neither of the effects comparing condition A and Condition A with tracking, or Condition B and Condition B with tracking, were significantly different in terms of response latency.

In order to determine whether the addition of the tracking task had any affect on overall response latency, contrast coefficients combining both single tasks (Condition A and B) were compared to both cognitive tasks with tracking (Cognitive A with tracking and Cognitive B with tracking). This comparison was significant ($p < .05$), indicating that the addition of a tracing task affect response latency for the

cognitive conditions. This finding is represented in Figure 5, which plots reaction time as a function of cognitive condition and tracking condition (on/off). Figure 5 indicates that while the slope representing performance differences between Condition A alone and Condition B alone is similar, overall reaction time was slower with the addition of the tracking task.

WORKLOAD

Table 4 shows the Mean Workload Scores by subscale for the NASA TLX. Workload scores were obtained for the following conditions: (1) tracking task, (2) Condition A, (3) Condition A with tracking, (4) Condition B, and (5) Condition B with tracking. Separate one-way analysis of variances (ANOVAs) with six factors (TLX subscales) were conducted on the data for each of the five conditions listed above. Table 5 shows the results of these analyses. The analysis demonstrated a significant difference between subscales for the following conditions: (1) Condition A with tracking, $F(5,40) = 3.13$, $p < .05$ (2) Condition B, $F(5,40) = 8.95$, $p < .001$, and (3) Condition B with tracking, $F(5,40) = 4.75$, $p < .01$. There were no significant differences between subscales for either tracking task; alone, or Condition A alone.

Table 4.

Mean Workload Scores For Each Task Condition.

CONDITION/SUBSCALE	MEAN TLX SCORE	STANDARD DEVIATION
Tracking/MD	31.7	29.4
Tracking/PD	41.1	19.0
Tracking/TD	38.3	25.4
Tracking/EF	57.8	20.5
Tracking/OP	40.0	23.7
Tracking/FR	46.1	24.2
Tracking/WWL	46.2	16.4
Cognitive (A)/MD	37.8	23.9
Cognitive (A)/PD	24.4	17.4
Cognitive (A)/TD	42.2	31.6
Cognitive (A)/EF	39.4	31.3
Cognitive (A)/OP	19.4	10.7
Cognitive (A)/FR	40.0	34.0
Cognitive (A)/WWL	36.0	17.4
Cognitive (A) w/Tracking/MD	61.1	26.2
Cognitive (A) w/Tracking/PD	65.6	17.2
Cognitive (A) w/Tracking/TD	52.8	25.9

Table 4.

Mean Workload Scores For Each Task Condition (Contd).

Cognitive (A) w/Tracking/EF	74.4	16.9
Cognitive (A) w/Tracking/OP	39.4	18.4
Cognitive (A) w/Tracking/FR	64.4	24.4
Cognitive (A) w/ Tracking/WWL	65.0	10.7
Cognitive (B)/MD	76.7	11.7
Cognitive (B)/PD	35.6	18.8
Cognitive (B)/TD	46.1	23.7
Cognitive (B)/EF	76.7	11.5
Cognitive (B)/OP	34.4	18.6
Cognitive (B)/FR	50.6	27.7
Cognitive (B)/WWL	62.3	9.7
Cognitive (B) w/Tracking/MD	88.3	8.7
Cognitive (B) w/Tracking/PD	72.8	26.8
Cognitive (B) w/Tracking/TD	67.8	18.9
Cognitive (B) w/Tracking/EF	87.8	16.8
Cognitive (B) w/Tracking/OP	53.3	20.9
Cognitive (B) w/Tracking/FR	68.9	21.3
Cognitive (B) w/Tracking/ WWL	78.3	11.6

In order to simplify the interpretation of the TLX, an additional ANOVA was conducted on the overall workload index (WWL) for all five conditions (see Table 5). Results showed a significant difference in workload between conditions, $\underline{F}(4,32) = 13.62$, $\underline{p} < .001$. As anticipated, the greatest overall workload was reported for dual task performance involving the cognitive task (Condition B) with tracking (TLX mean = 78.3), while the least workload was involved in performing Condition A alone (TLX mean = 36.0). Subjects generally found the tracking task more demanding (TLX mean = 46.2) than Condition A (TLX mean = 36.0). Mean WWL scores reflected the fact that subjects rated the cognitive task (Condition A) as least demanding overall, while the dual task situation (Condition B with tracking) was rated as most demanding in terms of workload.

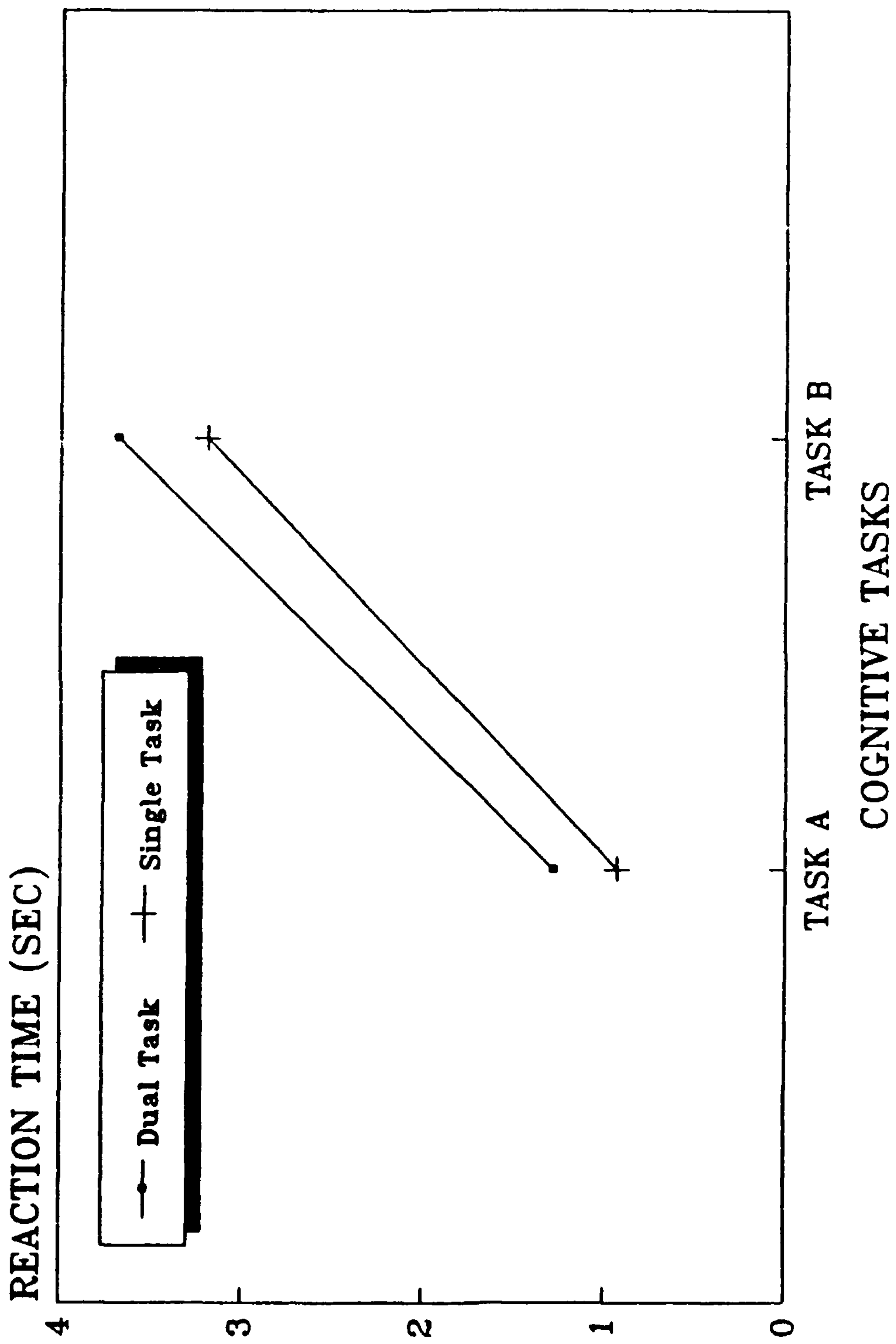

Figure 5. Performance as a Function of Cognitive Condition and Tracking.

Table 5.

Analysis Of Variance For Workload Scores (TLX).

EFFECT	df EFFECT	MS EFFECT	df ERROR	MS ERROR	F	p
Tracking	5	700.83	40	359.17	1.95	0.110
Cognitive (A)	5	811.11	40	502.57	1.61	0.180
Cognitive (A)/Tracking	5	1321.85	40	422.27	3.13	0.050
Cognitive (B)	5	3278.89	40	366.18	8.95	0.001
Cognitive (B)/Tracking	5	1591.85	40	335.39	4.75	0.010
WWL	4	2481.86	32	182.22	13.62	0.001

DISCUSSION

It is clear that performance on both tasks (tracking/cognitive), whether performed alone or in dual task situations, was representative of performance reported in the literature. That is, single task performance and, in general, resulted in better performance (at least in terms of response latencies). The only case where this did not occur was associated with Mean Correct Response. If one only looks at the percent correct across the four cognitive task conditions (Table 2), it becomes apparent that the addition of a tracking task does not affect Mean Correct Response. Not unless one examines the latency data, does it become apparent that performance differences do occur. Here we see a speed/accuracy trade-off, in that subjects apparently were taking more time to respond to a more difficult task, but were just as accurate as in the easier conditions. Thus, it seems that mean response latencies and workload (as measured by the TLX), are best able to discriminate between the five conditions designed in the current study.

The present study has demonstrated that tasks can be designed to capture data within relatively brief performance periods. In general, during a 15 second period, approximately 3 to 10 data points were collected during each session. Obviously, this wide range is due to the level of task difficulty experienced by the subjects. Thus, it would appear that "sufficient" data can be collected during a brief period of exposure to high G on the centrifuge. The second problem, that of separating sensory and cognitive components of performance, was resolved with the use of a modified Sternberg task. The key issue here, is whether the tasks are sensitive enough to distinguish what may be subtle effects attributable to cognitive and non-cognitive factors.

REFERENCES

1. Glaister, D.J., & Lisher, B.J. (1976). The Effect Of A Reclined Sitting Position On Psychomotor Performance During Exposure To High, Sustained +Gz Acceleration. FPRC Report No. 1362. Flying Personnel Research Committee, Ministry of Defence (Air Force Department), London.

2. Lisher, B.J., & Glaister, D.J. (1978). The Effect Of Acceleration And Seat Back Angle On Performance Of A Reaction Time Task. FPRC Report No. 1364. Flying Personnel Research Committee, Ministry of Defence (Air Force Department), London.

3. Rogers, D.B., Ashare, A.B., Smiles, K.A., Frazier, J.W., Skowronski, V.D., & Holden, F.M. (1973). Effect Of Modified Seat Angle On Air-To-Air Weapon System Performance Under High Acceleration. Aerospace Medical Research Laboratory, Wright-Patterson AFB, Ohio, 45433, AMRL-TR-73-5.

4. Sternberg, S. (1969). The Discovery Of Processing Stages. Acta Psychologica, 30, 276-315.

5. Hart, S.G., & Staveland, L.E. (1988). Development of a Multi-dimensional Workload Rating Scale: Results of Empirical and Theoretical Research. In P.A. Hancock and N. Meshkati (Eds.), Human Mental Workload (pp. 139-183), Amsterdam: Elsevier.

DISTRIBUTION LIST (Continued)
Report No. NADC-90065-60

	No. of Copies
U.S. Army Human Engineering Laboratory Aberdeen Proving Grounds, MD 21005-5001 (1 copy for J. Weisy, Directory) (1 copy for F. Malikin)	2
U.S. Air Force Flight Dynamics Laboratory, Wright Patterson AFB, OH 45433-6523 (1 copy for Dr. J. Reising, AFWAL/FIGRB) (1 copy for Dr. A. Mayer, AFWAL/FIER) (1 copy for B. J. White, AFWAL/FIER) (1 copy for CAPT Herbert, AFWAL/FIER)	4
U.S. Air Force Aerospace Division, Wright Patterson AFB, OH 45433-6523 (1 copy for B. Billings, ASD-ENECC)	1
U.S. Air Force Aeromedical Research Laboratory, Wright Patterson AFB, OH 45433-6523 (1 copy for Dr. W. Martin, AAMRL/HEA) (1 copy for Col. E. Vermulen, OL/AC HSD/yA (CAT))	2
Center for Naval Analysis 4401 Fort Avenue P.O. Box 16268 Alexandria, VA 22302-0268	1
1299th Physiological Training Flight Malcolm Grow USAF Medical Center Andrews AFB, Washington, DC 20331-5300	1

DISTRIBUTION LIST
Report No. NADC-90065-60

	No. of Copies
Defense Technical Information Center ATTN. DTIC-FDAB Cameron Station BG5 Alexandria, VA 22304-6145	2
Naval Air Development Center Warminster, PA 18974-5000 (2 copies for Code 8131) (15 copies for Code 60) (10 copies for Code 6021)	18
Naval Ordance Station Indian Head, MD 20640-5000 (1 copy for Charles Dieman, Code 5240)	1
Office of Naval Technology 800 N. Quincy St. Arlington, VA 22217-5000 (3 copies for W. King, Code 21)	3
Pacific Missile Test Center Point Mugu, CA 93042 (1 copy for Branch Head, Code 4025)	1
Naval Training Systems Center Orlando, FL 32813-7100 (1 copy for Branch Head, Code 73)	1
Naval Air Systems Command Washington, DC 20361-0001 (1 copy for T. Thomasson, AIR-931H) (1 copy for CAPT G. Speakman, AIR-531) (1 copy for H. Arnoff, AIR-5312) (1 copy for CAPT Hughes, AIR-531) (1 copy for T. Pavlick, AIR-5312)	5
Naval Air Test Center Patuxent River, MD 20670 (1 copy for Branch Head, Code SY 73)	1
Naval Personnel Research and Development Center San Diego, CA 92152-6800 (1 copy for J. Grossman, Code 71)	1
Naval Post Graduate School Monterey, CA 93943 (1 copy for LCDR T. Mitchell, Code 55)	1